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ACTS-94-023

in the long dimension, corresponding to a 0.736 free-space wavelength. The im-nce-matching transmission line sec- that feed adjacent elements differ ectrical length by 180°, so that ad-t elements are fed in opposite phase. , the antenna can be regarded as isting of two interleaved subarrays ed in opposite phase.

ie combined effect of interferences ng the electromagnetic fields radi- by the various elements in like and osite phases is to suppress the net ation in the broadside direction and coherently to produce the two off-dside beams at ±41.5°. These two off-broadside beams are the results of grating lobe radiation. The 3-dB width of each beam is 2.7°; the peak side-lobes are 15 dB below the main-beam peaks. In practice, imperfections of design and fabrication prevent exact cancellation of the broadside beam, which remains about 18 dB below either main beam. The measured peak gain at 5.29 GHz is 20 dB with respect to an isotropic antenna. The coaxial power divider and coaxial cables that feed the antenna account for about 1.5 dB of insertion loss.

This work was done by John Huang and Soren N. Madsen of Caltech for **NASA's Jet Propulsion Laboratory.** *For further information,* ***write in 83*** *on the TSP Request Card.*

In accordance with Public Law 96-517, the contractor has elected to retain title to this invention. Inquiries concerning rights for its commercial use should be addressed to

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Refer to NPO-18810, volume and number of this NASA Tech Briefs *issue, and the page number.*

Steerable K/Ka-band Antenna for Land-Mobile Satellite Applications

This antenna tracks and communicates with a geostationary satellite from the roof of a moving vehicle.

NASA's Jet Propulsion Laboratory, Pasadena, California

A prototype steerable microwave antenna tracks and communicates with a geostationary satellite. It is designed to be mounted on the roof of a vehicle (car, truck or van) and is only 10 cm tall. Together with a stationary ground terminal, the vehicle and satellite are parts of an experimental mobile-satellite communication system using NASA's Advanced Communications Technology Satellite (see Figure 1).

The antenna includes a feedhorn and an offset reflector mounted on a rotary table driven by a stepping motor. A layered dielectric radome protects these components (see Figure 2). The antenna handles both the 20 GHz, vertically polarized, received (downlink) beam and the 30 GHz, horizontally polarized, transmitted (uplink) beam, both with a 300 MHz bandwidth. It provides a peak receive sensitivity of –3 dB/K (gain to noise temperature ratio) and a peak transmit isotropic gain of 24 dB, while supporting transmit power levels up to 10 W. The transmitted and received beams are routed between the antenna and the equipment inside the vehicle via a coaxial rotary joint and a diplexer.

The position and orientation of the feedhorn on the rotary table are fixed, but the elevation angle of the reflector can be adjusted manually so that it matches that of the satellite in the geographical region in which the vehicle operates. The radiation patterns of the antenna at the two frequencies are broad enough to accommodate the typical tilting experienced by vehicles while traveling along paved roads.

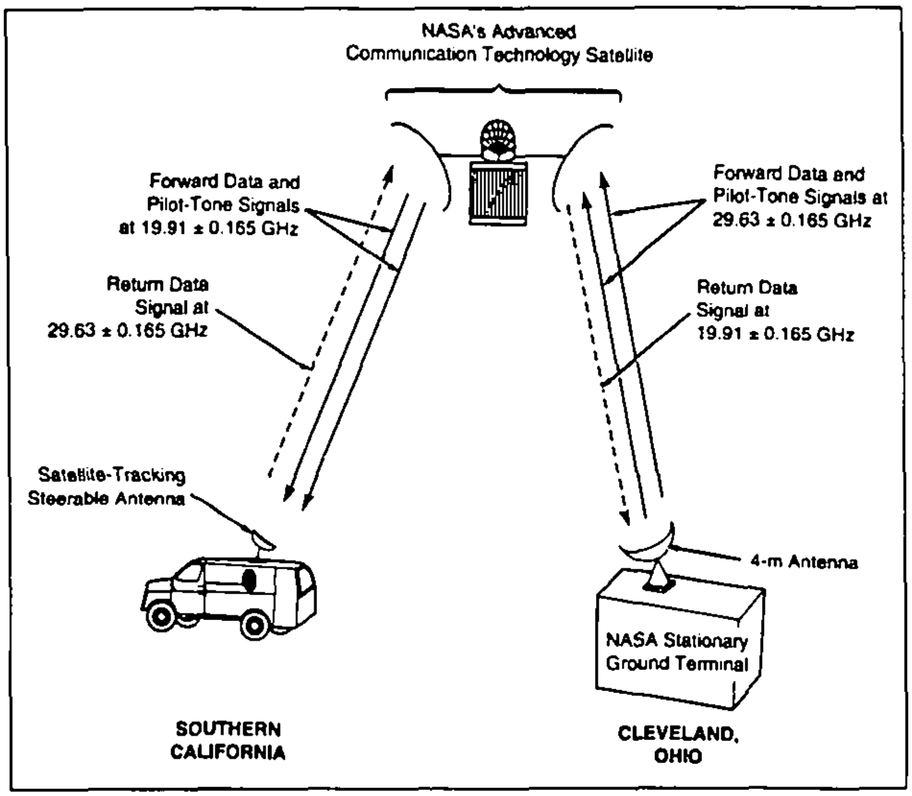

Figure 1. This **Experimental Communications System** is designed to demonstrate and test various aspects of mobile satellite communications. A principal subsystem — the subject of this article — is the steerable microwave antenna mounted on the roof of a van.

Under control of a computer mounted in the vehicle, the rotary table is turned so that the antenna acquires a pilot-tone signal that the satellite relays to the van from the stationary ground terminal. Once the pilot tone is acquired, an inertial turn-rate sensor mounted to the vehicle provides most of the information needed to keep the antenna pointed toward the satellite as the vehicle moves about, so that communications are sustained while traveling. Any residual azimuthal-angle pointing error that develops is detected by sinusoidally dithering the rotary table ±1° at a frequency of 2 Hz while monitoring the signal strength of the pilot

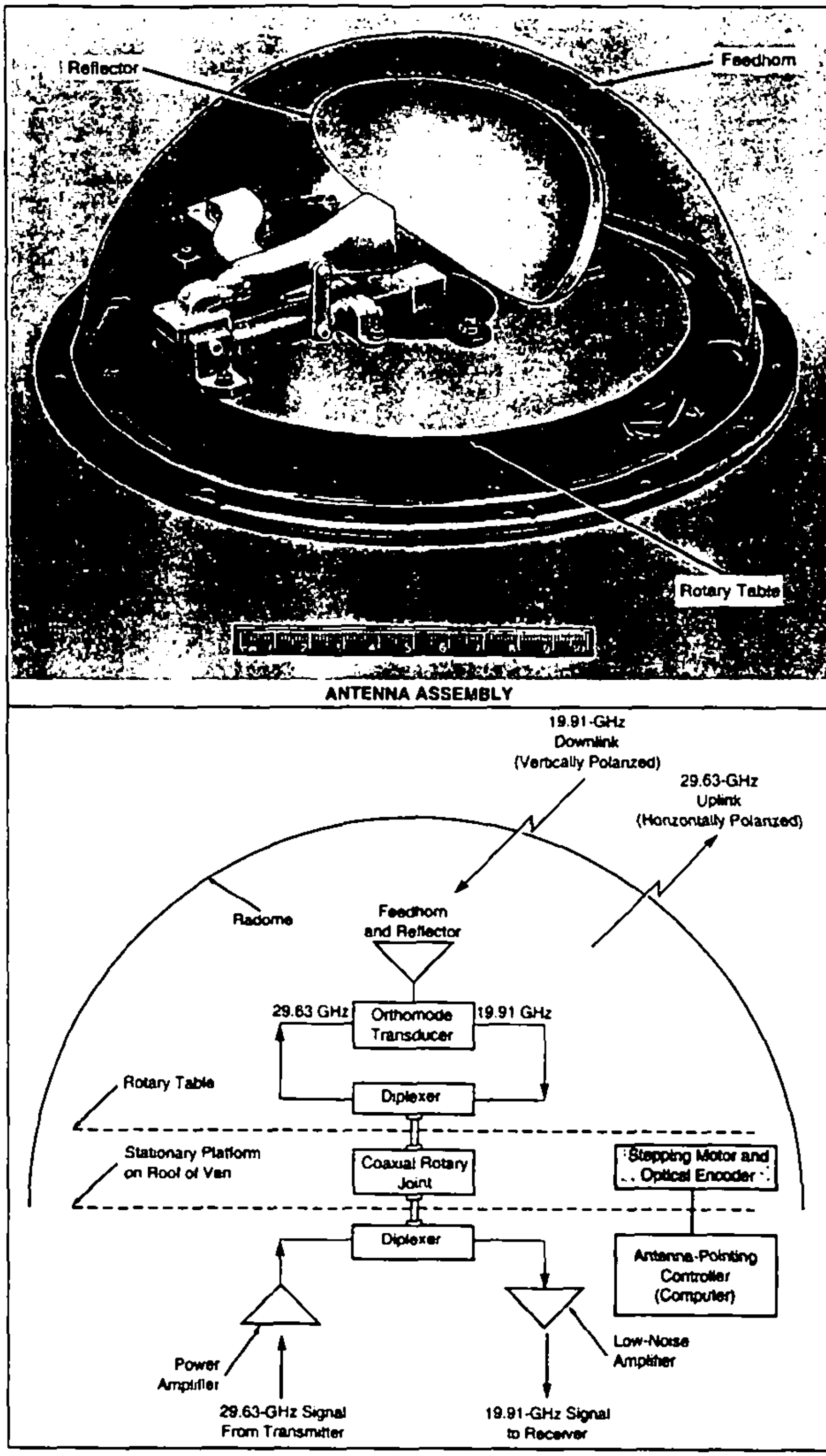

Figure 2. The **Steerable K/Ka-band Antenna** is made rugged and compact to suit the rooftop mobile operating environment. The more-delicate signal-processing and control equipment is located inside the vehicle.

tone received through the antenna. The resulting estimate of pointing error is the source of feedback for the antenna pointing subsystem.

The antenna system completes a full azimuthal scan and acquires the pilot tone in about 6 seconds. After acquisition and during tracking, the root-mean-square pointing error is only a small fraction of a degree. The system can compensate for vehicle turn rates up to 60°/s. If the pilot tone is temporarily lost (e.g., when the vehicle passes under a bridge) the inertial part of the antenna pointing subsystem continues to function, thereby facilitating immediate reacquisition.

This work was done by Arthur Densmore, Vahraz Jamnejad, and Kenneth

Woo of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information,* **write in 19** *on the TSP Request Card.*

This invention is owned by NASA, and a patent application has been filed. Inquiries concerning nonexclusive or exclusive license for its commercial development should be addressed to the Patent Counsel, NASA Resident Office–JPL [see page 20]. Refer to NPO-18772.

Frequency-Selective Microwave Reflectors

Multiple double-loop patch elements reflect at some frequencies and transmit at others.

NASA's Jet Propulsion Laboratory, Pasadena, California

Lightweight dichroic reflector panels are being developed for use in multiplexing electromagnetic waves at three or four microwave frequencies. The basic requirement is that the panels be highly reflective in the X and K_a bands and highly transmissive in the K_u and S bands. The original intended application is in the subreflector of a main paraboloidal reflector to enable simultaneous operation in both a prime-focus configuration in the K_u and S bands and a Cassegrain configuration in the X and K_a bands, as shown in Figure 1.

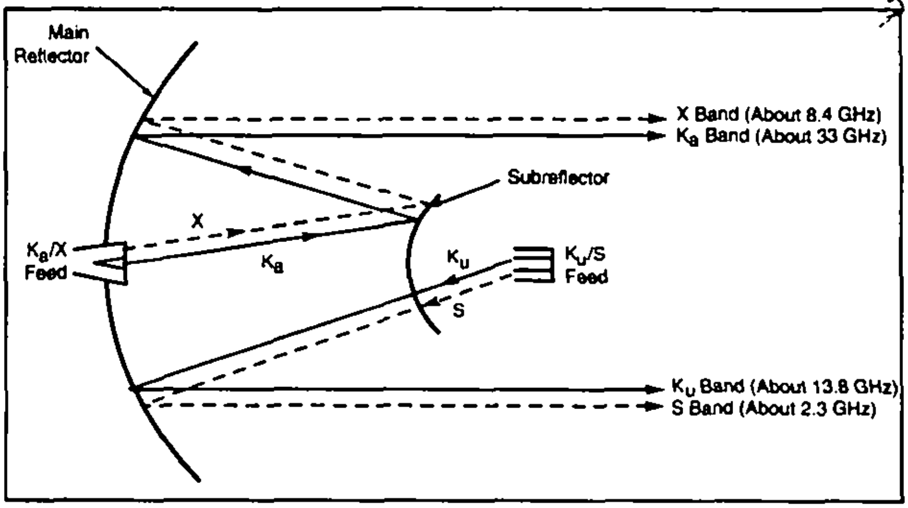

Figure 1. **Reflector Panels** are being developed for use in the subreflector of the dual reflector system. The subreflector is required to be highly reflective in the X and K_a bands and highly transmissive in the S and K_u bands.

The reflector panels are being designed according to two alternative approaches — add-on and integrated. In the add-on approach, each panel includes a lightweight dielectric (e.g., plastic foam or honeycomb) core that supports dichroic arrays of double-loop array elements on its front and back surfaces. The front-surface array is highly reflective in the K_a band and highly transmissive in the S, X, and K_u bands; the back-surface array is highly reflective in the X band but highly transmissive in the S and K_u bands. In the integrated approach, only one surface of the dielectric panel core supports an array of double-loop array elements that satisfies the basic frequency-selective reflection and transmission requirement.

The subreflector panels for the intended application will have to be curved, but for the sake of simplicity, the prototype panels that have been built and tested thus far have been made flat. Both square and circular double-loop antenna elements have been designed and have been fabricated by depositing patches of copper on thin dielectric sheets. The sheets have then been attached to the dielectric cores to form unitary sandwich structures. For example, Figure 2 shows a panel according to the add-on approach, with arrays of square double-loop array elements on polyimide sheets bonded to a foam core.

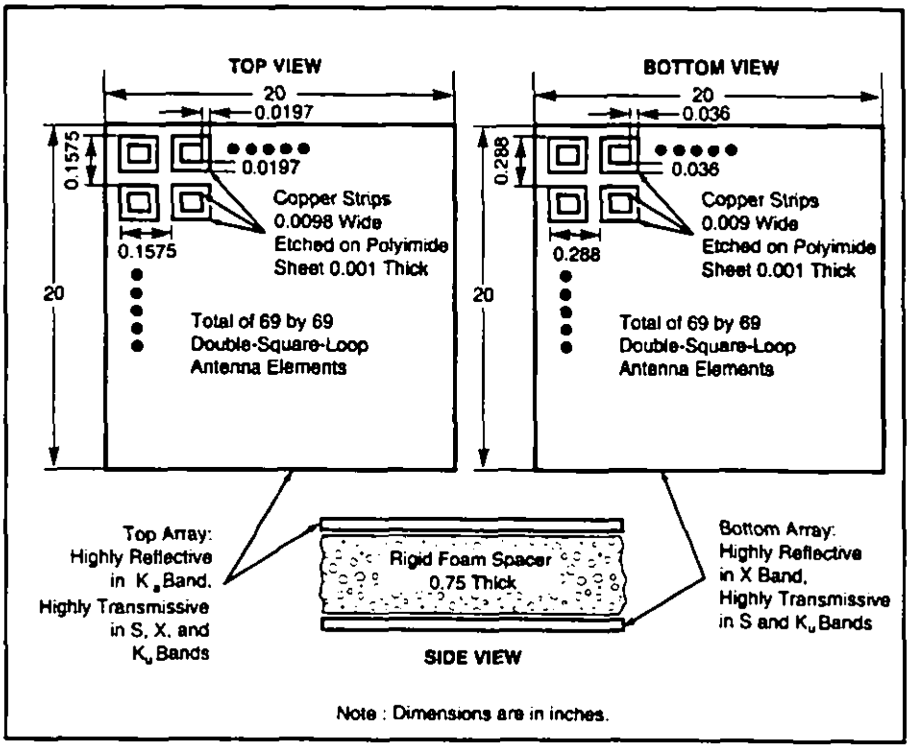

Figure 2. This **Flat Reflector Panel** of the add-on type includes two surface arrays of double-square-loop patch elements. This panel is one of several prototypes of the curved subreflector of Figure 1.

This work was done by Te-Kao Wu of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information,* **write in 4** *on the TSP Request Card.*

This invention is owned by NASA, and a patent application has been filed. Inquires concerning nonexclusive or exclusive license for its commercial development should be addressed to the Patent Counsel, NASA Resident Office – JPL [see page 20]. Refer to NPO-18701.